

NOAA Ocean Acidification Program Research Update

1 – Initiate monitoring of calcification rates of crustose coralline algae and reef-building sessile invertebrates

2 – Continue/Expand the study of calcification rates of key reef-building coral tax

3 – Initiate monitoring of biodiversity and ecosystem function shifts caused by ocean acidification

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Person submitting if different:

Laboratory/Science Center/Program: **Pacific Islands Fisheries Science Center (PIFSC)**

Year of Project Initiation: **2010**

The PIFSC Coral Reef Ecosystem Division (CRED) leverages significant sea time (~100 days per year), internal funding (NOAA Coral Reef Conservation Program (CRCP)), and external funding (NSF through Woods Hole Oceanographic Institution-Anne Cohen; Scripps Institution of Oceanography-Jen Smith/Nichole Price; Hawaii Institute of Marine Biology-Paul Jokiel; San Diego State University-Forest Rohwer; University of Florida-Gustav Paulay; and Smithsonian Institution-Nancy Knowlton/Chris Meyer) by monitoring the ecological and biodiversity impacts of ocean acidification in conjunction with the Pacific Reef Assessment and Monitoring Program (Pacific RAMP) cruises funded by CRCP, onboard the NOAA ship *Hi'ialakai*.

1 – Initiate monitoring of calcification rates of crustose coralline algae and reef-building sessile invertebrates

Status of the Research:

Calcification Acidification Units (CAUs) have been developed in collaboration with Scripps Institution of Oceanography as a proxy to measure and compare spatial patterns of net carbonate production on coral reefs across the U.S. jurisdictional-affiliated Pacific Islands. Analysis of the CAUs will establish comparative baselines of accretion in a wide range of oceanographic and benthic habitats and allow for temporal monitoring of the effects of ocean acidification. The calcification data are closely correlated with environmental factors, such as water temperature and pH and because of this, CRED collects discrete water samples at each CAU site. Developing baselines of carbonate production over a wide spatial area will advance the understanding of how calcification rates are changing over time and improve our ability to predict changes in carbonate production in a high-CO₂ world.

CAUs have been deployed at 24 islands across 4 U.S. Pacific jurisdictions that CRED monitors: the Northwestern Hawaiian Islands, the Pacific Remote Island Areas (PRIAs), American Samoa, and the Marianas (CNMI and Guam) (Table 1, Fig. 1-2). Due to delays in permit review and approval by the Hawaii DAR in 2010, the MHI is the only jurisdiction where CAUs have not been deployed. The permit review process has been re-initiated by DAR and CRED has submitted a permit request for CAU installation during the next MHI RAMP cruise.

Beginning in January 2010, a total of 10 researchers have assisted in the installation process over 165 sea days. The first recovery of CAUs will begin in January 2012. CRED is currently setting up a lab to begin processing recovered CAUs at the completion of the 2012 ASPacific RAMP cruise to American Samoa and the PRIA. A baseline of net carbonate production of CCA and reef-building invertebrates and net productivity will be the result of this initial analysis. Work is planned to take high-resolution photographs of each CAU recovered. Through collaboration with SIO, these images will be analyzed to determine community composition on the plates and species-specific recruitment rates. This will provide information regarding mineralogy (Mg vs. Ca carbonate) based on what organisms are present.

Relevant Papers and Presentations:

Nichole Price, Todd Martz, Russell E. Brainard, Jennifer E. Smith (in review). Variability in daily pH maxima limits coral reef accretion and community structure.

Funding Update:

100% of funds have been obligated for research staff support and equipment.

2 – Continue/Expand the study of calcification rates of key reef-building coral taxa

Status of the Research:

Analyses of coral cores collected across the U.S.-affiliated Pacific Ocean Islands allows CRED to collect historical records of the growth and calcification rates of reef-building corals existing in a wide range of oceanographic and benthic habitats. Growth rates from coral cores are closely correlated with environmental stressors, such as water temperature and ocean acidification, and CRED collects discrete water samples at each coral coring site for this reason. Developing historical records of corals over a wide spatial area will advance the understanding of how growth rates have changed over time across the Pacific Ocean and improve our ability to predict future changes in coral growth and calcification in a high-CO₂ world.

Eighteen coral cores were collected during the 2010 American Samoa RAMP cruise and twelve coral cores were collected during the 2011 Mariana Islands Archipelago RAMP cruise (Table 1, Fig. 1, 3-4). The cores were collected using SCUBA divers and pneumatic drills. The coral core analyses are performed through collaboration with Dr. Anne Cohen of Woods Hole Oceanographic Institution. Dr. Cohen has developed a non-destructive investigative technique that uses a CT-Scan to create 2-D and 3-D images of each coral core. The coral cores collected during the American Samoa cruise have been analyzed and initial data reduction has commenced (see “Data products” below). The coral cores collected on the Mariana cruise represent a variety of benthic habitats; most interesting is a core from a shallow hydrothermal vent system found near the island of Maug. The reason this core could be of interest is that the surrounding waters are much more acidic (~pH 6.1) than the ambient seawater in the region (~pH 8.2). Although the coral cores from the FY11 cruise have yet to be analyzed, we expect the growth and calcification rates of the coral community sampled near the vent system to be very different than those observed at other locations around Maug, and the rest of the archipelago.

Funding Update:

100% of the NMFS funds obligated to this project were spent on staff support, operations, and supplies. For FY12, we look forward to the opportunity to propose continuing our coral core collection throughout the Pacific Ocean, thus expanding our spatial coverage, and employ the use of a larger coral coring drill that is within CRED’s equipment inventory. A larger coring capability on the Pacific RAMP cruises will allow the extraction of coral cores with a much longer historical record (from ~20 yrs to ~200 yrs). With coral growth records reaching further back in time, CRED scientists will have the opportunity to correlate decadal environmental histories with each coral community sampled.

Relevant Papers and Presentations:

AGU 2011, Dr. Anne Cohen will present “Coral Calcification Across a Natural Gradient in Ocean Acidification” in which results from discrete water samples and coral cores, provided by CRED, will help illustrate variability in calcification rates across the world’s oceans.

CRED is currently compiling in-house carbonate chemistry data for an upcoming manuscript investigating spatial and temporal variability in aragonite saturation states observed within the reef ecosystems monitored across the U.S. Pacific Islands.

3 – Initiate monitoring of biodiversity and ecosystem function shifts caused by ocean acidification

Status of the Research:

Autonomous Reef Monitoring Structures (ARMS) have been developed to assess and monitor shifts in the cryptobiota diversity overtime along biogeographic, environmental, oceanographic, and human gradients in the U.S. Jurisdictional Pacific. The cryptobiota represent the most diverse group of organisms that inhabit the complex architecture of a coral reef and are vulnerable to direct and indirect impacts of ocean acidification as their calcification processes, life histories, functionality, and habitats respond to changing carbonate chemistry. By developing baselines of biodiversity, we will advance our understanding of these understudied communities and overtime, measure the

changes in this benthic community in response to ocean acidification. Understanding the impacts of ocean acidification on biodiversity is essential due to the role of biodiversity in maintaining ecosystem resilience.

Over 190 ARMS were recovered and 180 deployed in the U.S. Pacific Islands during FY10 and FY11 in conjunction with Pacific RAMP research cruises (Table 1; Fig. 1, 5-7). Beyond field activities, staff and interns have (1) initiated the photo analysis of the sessile communities that recruited to the ARMS plates; (2) initiated the morphospecies processing of organisms > 2 mm to understand and document community composition and functionality; (3) identified most of the brachyuran crabs obtained from ARMS collected in the Hawaiian and Mariana Archipelagos to genus; and (4) initiated diversity measurements and analysis on brachyuran biogeographic, environmental, oceanographic, and human gradients within the Hawaiian Archipelago.

Relevant Papers and Presentations, FY11:

Brainard R, Timmers M, Caley J, Knowlton N, Machida R, Meyer C, Moews M, Pauley G, Plaisance L, Rohwer F, Toonen R (2011) Autonomous Reef Monitoring Structures (ARMS): a systematic tool to assess global patterns and temporal trends in coral reef biodiversity. World Conference on Marine Biodiversity, Aberdeen, Scotland (Oral presentation).

Plaisance L, Brainard R, Caley MJ, Knowlton N (2011) Estimating the global diversity of coral reefs using standardized quantitative sampling and DNA barcoding: A comparison of geographic and habitat differentiation. Diversity – *In review* www.mdpi.com/journal/diversity.

Timmers M, Godwin S, Grimshaw K, Sudnovsky M, Brainard R (2011) Using Autonomous Reef Monitoring Structures to assess patterns of brachyuran diversity across the Hawaiian Archipelago. World Conference on Marine Biodiversity, Aberdeen, Scotland (Oral presentation).

Funding Update:

100% of funds have been obligated for research staff support and equipment. For FY12, we look forward to the opportunity to propose continuing our ARMS recovery, deployment, and associated analyses.

Table 1: Summary of CRED Field Accomplishments in the U.S. Jurisdiction Pacific Islands

	CAUs Deployed, to date	Cores Retrieved	ARMS Recovered, to date	ARMS Deployed, to date
FY 2010 RAMP Cruises				
American Samoa	200	4	33	39
Pacific Remote Island Areas	215	14	45	51
Northwestern Hawaiian Islands	100	--	34	33
FY 2011 RAMP Cruises				
Main Hawaiian Islands	--	--	37	18
Mariana Islands	200	10	36	39
Wake Atoll	25	2	9	9
Total	740	30	194	189

Figure 1: CRED Survey Areas

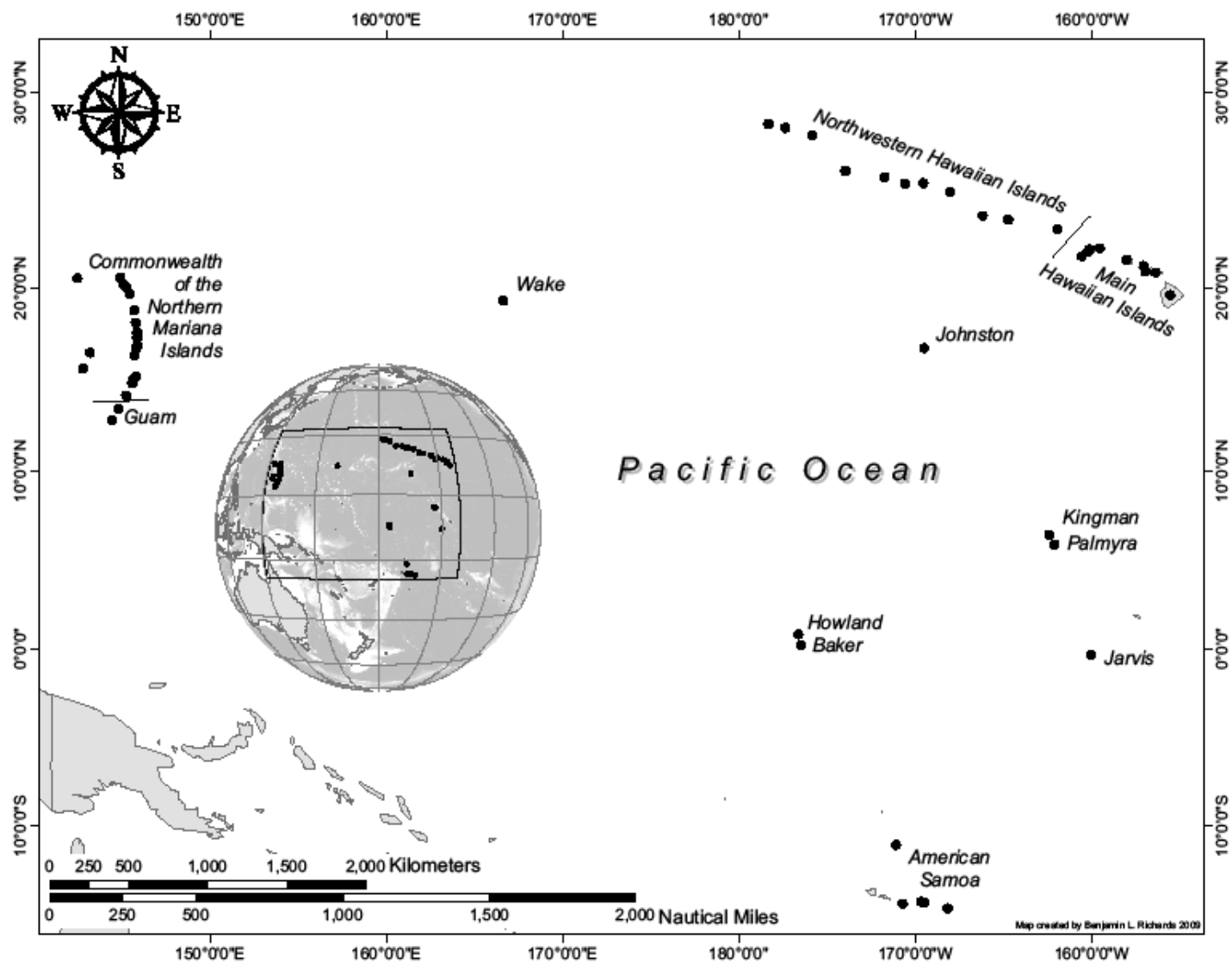


Figure 2: CAU Deployments

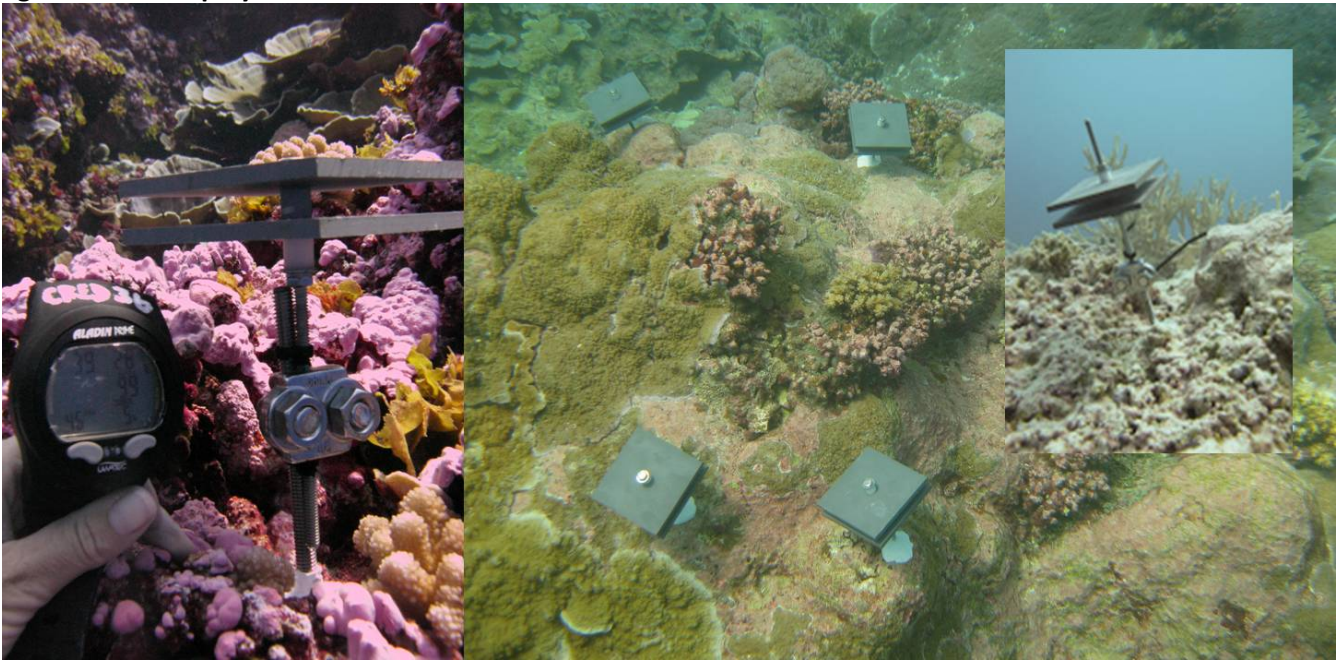


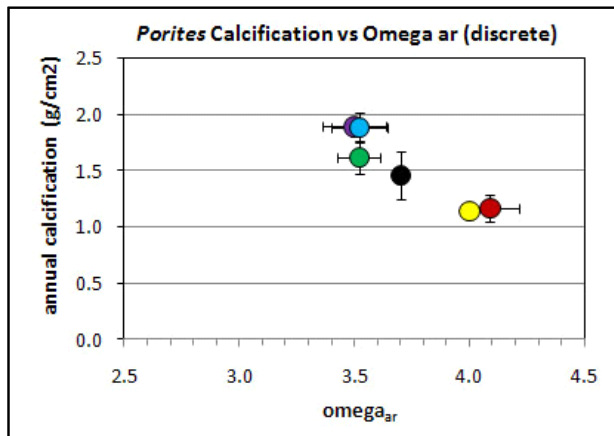
Figure 3: Coral coring by CRED scientific divers



Figure 4: Coral coring data products

Coral cores taken by CRED (FY10) during American Samoa RAMP

Complementary carbonate chemistry data collected by CRED scientific divers and additional coral cores collected by Dr. Cohen in the Red Sea and Great Barrier reef provide a reference/comparison to the corals monitored by CRED.



CRED Cores:

Green = Jarvis
Blue = Kingman
Purple = Palmyra
Yellow = Rose

Comparison Cores:

Red = Red Sea
Black = GBR

Examples of the imaging provided by CT-Scan

Note:

A.) 2-D banding.

B.) 3-D composite image.

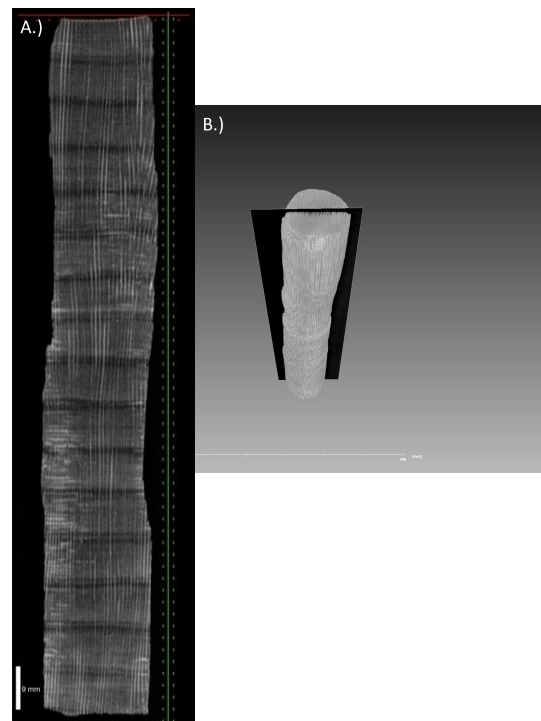


Figure 5: ARMS deployment and Recovery

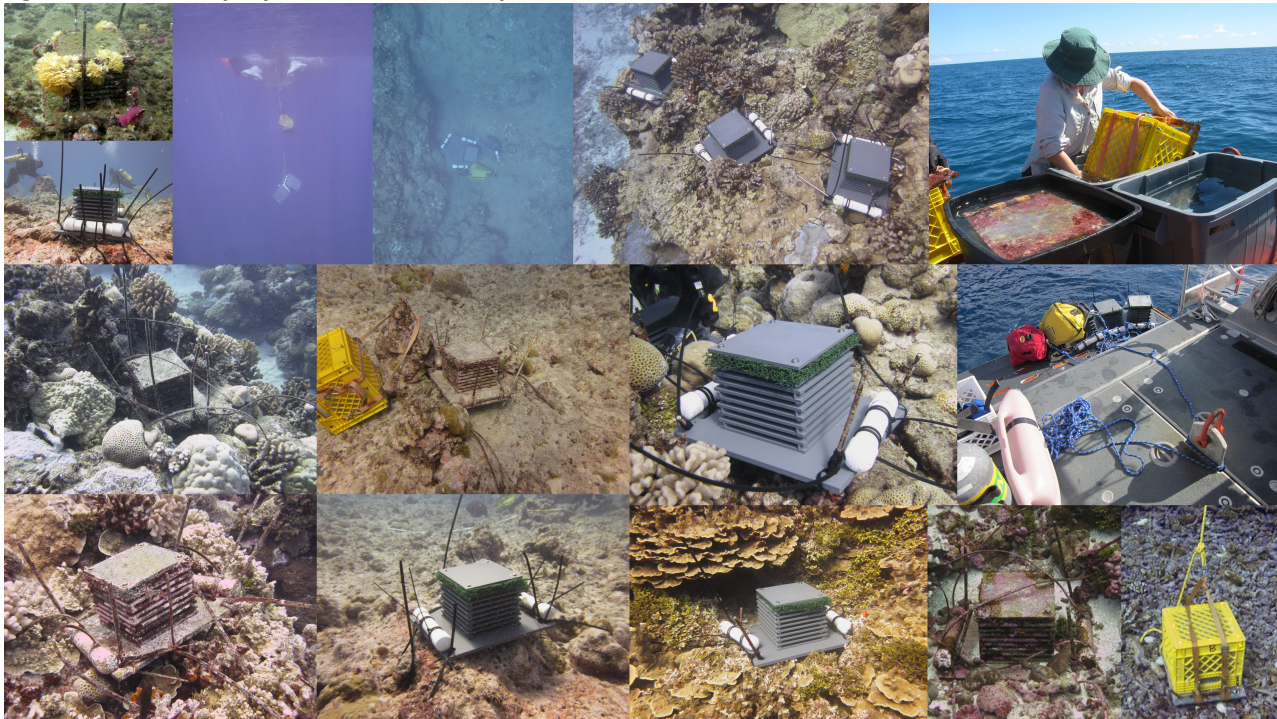


Figure 6: Ship-board ARMS processing



Figure 7: Cryptobiota found within ARMS units.

